

Vice Chancellor for Academic Affairs and Research

January 15, 2009

EXHIBIT 56  
DATE 1/23/09  
HR 5

Governor Brian Schweitzer  
State of Montana  
State Capitol  
Helena, Montana 59620

Mr. Dick Clark  
State of Montana Chief Information Officer  
State Capitol  
Helena, Montana 59620

Mr. Evan Barrett  
State of Montana Chief Business Officer  
State Capitol  
Helena, Montana 59620

Dear Governor and Chief Officers:

Attached herewith is the initial draft of a business plan/study for supercomputing/high performance computing (HPC) operations in Montana as per our contract with ITSD.

This Business Plan is a living document and we expect to work with you on additional adjustments in it as the fiscal year continues. Rather than just being a study, it represents and is resulting in the movement to an ongoing operation of a supercomputer center for all of Montana. It reflects the integration of the purchase of hardware, software and peripherals from appropriations to ITSD and OCHE, integration with Montana Economic Revitalization & Development Institute (MERDI) which is housing the supercomputer, further integration with the Rocky Mountain Supercomputer Centers, Inc. (RMSC), a private non-profit Montana Corporation which will manage, operate and market the State's IBM supercomputer activity under contract with ITSD.

Again, we have gone one step further than just doing a study. Under your strong direction, we have structured the plan so as to bring this effort from concept to reality in order to make sure that Montana's government, academia and businesses are rapidly competitive in the new technology environment.

The ITSD IBM Supercomputer is currently installed in Historic Uptown Butte in the data center of the Thornton Building at MERDI. During our study/planning we determined that the infrastructural strength around the Thornton Building as well as space and accessibility issues on the Tech campus, warranted the Tech/ITSD supercomputer to be off campus in an appropriate accessible, expandable and technologically strong environment. We expect the supercomputer to be fully functional and accepting new customers after the "burn-in" and "cluster enablement" take place in the next several weeks with the heavy involvement of IBM.

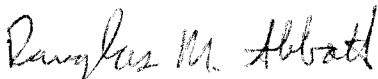
We believe that this business plan/study represents a unique model that can serve Montana's needs for economic growth, diversity and technology advancement in the form of a public/private/academic partnership that will save the state millions of dollars in unnecessary and hard to replicate hardware costs by utilizing a unique "on-demand" service delivery model, one of the first in the nation.

We are further enthused about the wide reach of the Supercomputer effort throughout the state via Centers of Excellence and Certified Regional (Economic) Development Corporations. All of Montana can and should benefit as this important project rolls out.

On behalf of Montana Tech and the Montana University System, we look forward to continuing to work with the State of Montana, RMSC, MERDI and IBM to further perfect this business plan/study and look forward to the legislature committing additional and adequate financial resources to ITSD to the project to help carry through the initial years of operation until the project reaches the desired objective of economic self-sustainability for Montana's cutting-edge Supercomputer operations.

Thank you for this opportunity to participate in this critically important state-wide project for the future of all of Montana.

Sincerely,

A handwritten signature in cursive script, reading "Douglas M. Abbott".

Dr. Douglas M. Abbott  
Vice Chancellor for Academic Affairs and Research

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HB 5



*Generating a Technology*

*Future Worthy of Montana—*

# An Initial Supercomputing Business Plan Promoting Business and Economic Development for the State of Montana

January 2009

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"Supercomputing is essential to maintaining and extending America's economic competitiveness"  
DOE Secretary Samuel Bodman  
November 15, 2006

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# Executive Summary

## ***Rocky Mountain Supercomputing Centers (RMSC)***

The State of Montana has reached a crossroads in its history. This twenty-first century intersection presents an opportunity to revitalize traditional industries while laying a foundation for innovation across multiple emerging economic sectors. Supercomputing<sup>1</sup> represents a cornerstone of this innovation foundation and supports Montana's global competitiveness, quality-of-life, and strategic positioning within a knowledge-based economy.

This business plan developed by the Rocky Mountain Supercomputing Centers, Inc. (RMSC) as a non-profit corporate contract agent of the state of Montana, outlines a technology future worthy of Montana, designed by Montanans, for Montanans. RMSC presents a novel business model for cementing this cornerstone as one of the key initiatives for pervasive economic development across the State of Montana. When someone hears of or thinks of RMSC, it will always communicate to mean the Rocky Mountain Supercomputing Centers, Inc. and be understood to represent its vision and mission for the State of Montana.

Utilizing a distributed Center of Excellence (COE) concept and an agile governance model inherently linked to well-established strategic economic development initiatives, RMSC recognizes the future of HPC as a distributed, on-demand approach through a combined public and private sector governance model. Seeking to foster Montana's entrepreneurial spirit, RMSC elevates supercomputing as a way of stimulating innovation across multiple lines of economic activity across our extensive and economically diverse geography.

RMSC secures Montana's position as a recognized world leader in supercomputing solutions in the following endeavors:

- alternative energy production, exploration and transmission,
- advanced engineering simulation and visualization,
- advanced agricultural forecasting and modeling,
- climate-land interaction modeling,
- pharmaceutical and health sciences\health care,
- integrated land-use planning,
- advanced geospatial analytics and visualization,
- world-class academic research and applied sciences,
- national and homeland security challenges,
- natural resource management, including fire behavior and fire effects modeling,
- high-end, specialty electronic manufacturing, and much more.

RMSC, on behalf of State of Montana, views supercomputing as a means to an economic end whereby we are limited only by our imaginations. Supercomputing provides the necessary and vital computational power to address problems that are currently simply unapproachable given conventional computing systems, and represents a paradigm shift in how businesses and research institutions pursue answers to complex problems. RMSC seeks to leverage the future of supercomputing as an "on-demand" series of utility services within a distributed cyberinfrastructure. Emphasis is placed on harnessing the power of the supercomputing network as

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<sup>1</sup> For purposes of this business plan, "supercomputing" and "high performance computing" are terms used interchangeably and carry the same connotation. These terms can be defined as: A computing system that provides more computing performance, power, or resource than is generally available. Sufficient memory to store large problem sets, computer memory, throughput, computational rates, and other related computer capabilities contribute to significant computing performance not available through additional computing configurations. Source: Cornell University Center for Advanced Computing Glossary of High Performance Computing Terms.

a transaction-based approach, investing capital in the development of supercomputing capacity and the human expertise necessary to harness supercomputing successfully. The capital investment target of RMSC is toward controlled capital expenditures in hardware (expensive and transitory) and expansive investment in capacity, demand, and human expertise.

RMSC, on behalf of State of Montana, projects return on investment in pervasive intellectual property growth, next-generation software application development designed for supercomputing capabilities, business efficiencies involved in product and services delivery, novel inventions and discoveries, and the competitiveness returned through essential and viable innovation. As a non-profit, on behalf of State of Montana, RMSC returns any and all proceeds into the HPC mission of the state of Montana.

In sum, RMSC represents a collaborative (public, private, academic & governmental approach to supercomputing in the State of Montana, and embraces a pervasive and distributed model consistent with significant information technology trends. Our collective investment in the RMSC cornerstone helps ensure that Montana's economic future rests upon a solid foundation positioned to embrace that future.

### ***RMSC Vision***

...To establish the State of Montana as a recognized global leader in High Performance Computing (HPC), utilizing a next generation business model as a fundamental component of its economic growth engine.

This vision will be realized by:

- Crossing a critical cyberinfrastructure threshold—realizing enough computing horsepower to win commercial customers and federal grants
- Becoming the nation's first "services-based" HPC business model leveraging economies of scale
- Achieving "on-demand" High Performance Computing (HPC) capabilities
- Focusing on the investment in human capital as the critical component of the RMSC vision.

### ***RMSC Mission***

...To enable next-generation discoveries, advancements and solutions for commercial, academic, and governmental stakeholders through the utilization of high performance computing applications and services.

- Through its Stakeholders:
- Secure sustainable growth through multiple funding mechanisms
- Advance competitiveness across multiple economic sectors
- Support the expansion of the State of Montana's economy in the global marketplace.

### ***Linkage to Montana Certified Regional (Economic) Development Offices***

A core tenant of the RMSC governance model, along with its business, operational, and staffing models, is to link direct HPC technical and development activities to the existing Montana Certified Regional (Economic) Development Corporations (CRDCs) and the areas they represent. A major (new) function of each of the state's Regional Economic Development Officers (RDO) will be to support the creation and management of a Center of Excellence that will support the RMSC Mission and the CRDC constituency.

### ***Center of Excellence (COE)***

A Center of Excellence (COE) is a formally created, chartered, certified, and accepted technical body of knowledge and experience on given subject area. The COE is formed with support of a Certified Regional (Economic) Development Corporation (CRDC). RMSC will formally advise, charter, accredit (a pre-cursor to certification), certify, and review (annual auditing) each COE that an RDO creates and operates within its area of interest.

A COE will be structured in accordance with its primary targeted audience. Two categories of COEs exist and are defined as follows.

- Business Development (BD)—targeted to commercial firms, entrepreneurial development activities, industry ventures, and joint venture or collaborative partnerships with key vendors and industry.
- Research and Development (R&D)—targeting universities, colleges, and academic institutions; additional effort to seek and secure state and federal grants will be pursued.

### ***RMSC Business Model***

RMSC will deliver supercomputing services via the services-oriented business model. Supercomputing services to corporate or industry partnerships, academia, and governmental groups will include:

- Timeshare (rental) of computation, data, and visualization resources as services;
- Applications and algorithms optimization and development services;
- Project and program management-based services;
- Intellectual property and technology transfer services; and
- Training, educational and outreach services.

Cyberinfrastructure components (computational nodes, high-bandwidth networks, storage systems, etc.) will be "procured" as service level agreements (SLAs) from the State of Montana's ITSD resources. RMSC will focus on the business development aspects of supercomputing—ITSD will own and maintain the cyberinfrastructure used by RMSC. This allows the State to maximize its purchasing power, maintenance schedules, and support staffing resources and RMSC to focus on delivering technical services and business development, while maximizing return on investment and de-emphasizing depreciation of capital in the form of computer hardware. Less investment in machinery or hardware means more investment in people, technical expertise and ultimately the final product.

### ***Financial Summary: Revenue Projections***

<b>Consulting Services</b>					
Algorithm Development Assistance	42,500	130,000	260,000	260,000	390,000
COE Formation and Certification	3,400	8,500	10,200	11,900	13,600
Scientific Visualization Services	-	15,000	42,500	42,500	63,750
Training	6,800	17,000	18,700	20,400	22,100
<b>Big Sky Leased Time</b>					
CPU Time	107,100	317,016	471,240	514,080	514,080
Storage Utilization	3,856	11,413	16,965	18,507	18,507
<b>DCCoD Leased Time</b>					
DCCoD RU's - Large Job	-	-	385,560	385,560	578,340
DCCoD RU's - Medium Job	-	148,512	371,280	371,280	891,072
DCCoD RU's - Small Job	22,032	66,096	110,160	110,160	110,160
<b>Grants</b>					
Butte Silver Bow	-	-	-	-	-
State of Montana	-	-	-	-	-
Federal Government	-	-	-	-	-
<b>Total Revenue</b>	<b>185,688</b>	<b>713,537</b>	<b>1,686,605</b>	<b>1,734,387</b>	<b>2,601,609</b>

## LFD Questions

The State of Montana's Legislative Fiscal Division (LFD) Budget Analysis team for DP 6109 (High Performance Computing Operations) has asked the following questions. RMSC and ITSD respond to these questions as follows.

QUESTION: How will the state benefit from funding the startup of this business venture?

ANSWER: The vision and mission of the Rocky Mountain Supercomputing Centers, Inc. (RMSC) is to work with the State of Montana's ITSD high performance computing (HPC) capability (supercomputer) to establish Montana as a recognized leader in the execution of a next-generation supercomputing business model as a fundamental component of Montana's economic engine. RMSC and its Centers of Excellence (COEs), utilizing the state's HPC will enable future discoveries, advancements and solutions for commercial, academic and governmental customers through the use of supercomputing applications and on demand services. This HPC collaboration between the State of Montana ITSD and RMSC is a State-wide, public-private partnership initiative with local, regional and international connectivity and collaborations. The RMSC/State collaboration is about "Creating a technology future worthy of Montana."

QUESTION: How will these benefits be determined, measured, and reported?

ANSWER: RMSC's plan to success is through its novel public-private partnership business model, not the supercomputing hardware. The business model, including "on-demand services" minimizes capital expenditure requirements for HPC capability (a daunting hardware cost number) while emphasizing expenditures related to upgrading the human skills to deliver the services in a cost effective manner. Benefits to Montana are determined to be new high-technology, highly-paid jobs. Job growth is measured by each Center of Excellence (COE) across the state. RMSC will report job growth annually via a publicly published report.

QUESTION: How many jobs would be created and at what wage levels would jobs provide?

ANSWER: High-technology, highly-paid jobs are categorized as follows: a) Business Innovation; and b) Research (R&D). Net-new job growth for 2009-2013 is conservatively projected as: a) 170 Business Innovation jobs; and b) 83 Research (R&D) jobs. This is a conservative total of 253 net-new high-technology, highly paid jobs. We hope to do much better.

QUESTION: What level of customer commitment has been secured to fund future costs for the center?

ANSWER: RMSC has not "opened its doors" for service yet, although that will happen in the next several weeks, and thus, secured commercial and research commitments are still pending. It is projected that funding self-sustainability for the RMSC/State of Montana HPC will be achieved by Year 5 of the RMSC Business Plan Proforma. Customers of RMSC and the State supercomputing resources come through Centers of Excellence (COEs) across the state and we also expect to generate some out-of-state (regional and national) business, as well. RMSC has already chartered three (3) COEs today with at least three (3) more pending. Currently anticipated COE customers will include the US Air Force and potential grants from the US Department of Energy and US Department of Defense, which will be working with and through researchers in the University System and with the COEs and affiliated private research firms.

QUESTION: Does the state expect to see a direct return on this investment or would the return be in indirect economic development benefits? "

ANSWER: The State expects to see an indirect return on its investment (ROI) via the economic growth of high-technology, highly-paid jobs. These jobs are linked to the Centers of Excellence (COEs) and Regional Economic Development Centers/Corporations across the entire state. It is expected to generate personal and corporate income taxes from the jobs and the businesses involved as well as to trigger a good multiplier effect given the anticipated quality of the jobs.

## **Introduction**

### ***Venture Name***

Rocky Mountain Supercomputing Centers, Inc. (RMSC)

### ***Campaign Theme or Tag Line***

"...Creating a technology future worthy of Montana..."

### ***RMSC Legal Entity***

501(c)(3) not-for-profit corporation incorporated in the State of Montana, acting as an agent of the state of Montana under contract to the Montana ITSD, owner of the state's HPC..

### ***RMSC Vision Statement***

...To establish the State of Montana as a recognized global leader in High Performance Computing (HPC), utilizing a next generation business model as a fundamental component of its economic growth engine.

This vision will be realized by:

- Crossing a critical cyberinfrastructure threshold—have enough compute horsepower to win commercial customers and federal grants
- Becoming the first in the nation for a "services-based" HPC business model leveraging economies of scale
- Achieving "on-demand" High Performance Computing (HPC) capabilities
- Focusing on the investment in human capital as the critical component of the RMSC vision.

### ***RMSC Mission Statement***

...To enable next-generation discoveries, advancements and solutions for commercial, academic, and governmental stakeholders through the utilization of high performance computing applications and services.

- Through its Stakeholders:
- Secure sustainable growth through multiple funding mechanisms
- Advance competitiveness across multiple economic sectors
- Support the expansion of the State of Montana's economy in the global marketplace.

### ***Imperative Communications to Constituents***

With the success supercomputing cyberinfrastructure build-out and operation of the RMSC, the State can answer the following key questions (publicly and privately). These critical communication messages will take the form: Question➡Message➡Proof➡Significance.

### ***Why Montana?***

Montana lacks a supercomputing cyberinfrastructure and the corporate awareness for large-scale investments.

### ***Why supercomputing cyberinfrastructure?***

Supercomputing drives high-tech job creation and will create commercial collaborations in the region. The community of practice and professions created by this cyberinfrastructure will also attract the Montana diaspora.

### ***Why now?***

Montana has a favorable political and latent business environment. Montana is primed for investment and growth because of its aligned relationships with supportive corporations and governments.

## **Why the investment?**

The initial investment is required to create the governance model and cyberinfrastructure framework. For the immediate and continued success of RMSC, the base investment is required to set up the facilities and attract grants and partnerships.

## **Why eventual self-sustainability?**

Reduce tax payer burden and continual State appropriations. By aligning with industry and academia and their distinct supercomputing needs, RMSC's growth and expansion will be funded by ongoing business development.

## ***Venture Purpose and Description***

RMSC resources will be applied to the full spectrum of product and services development by its clients, industry and academic partners including:

- Basic and applied research
- Application development
- Testing and validation of hard and physical assets
- Scientific, business, and entrepreneurial visitors
- Long-term industrial partnerships
- Governmental (local, regional, national, international) partnerships
- Collaboration, outreach, and educational programs
- Technology incubation, commercialization transfer, and Commercial production

RMSC is one of several means to an end that will enable objectives and goals set by the state of Montana through its Chief Executive, the Governor, the Legislature and the needs of business and industry. A key differentiator in purpose for the RMSC is the focus on people development, skills training, and applicable technologies and not on classic "brick-and-mortar" infrastructure (i.e., buildings) that some states have focused on. Implicit in the RMSC model is a shared stakeholder model between private and public investments, distribution of risk, and the ability to offer competitive computing resources to multiple users. Other HPC efforts have failed that have been completed dominated or managed by government and/or university entities. Thus, the need for a strong private-public partnership to drive the Montana model is crucial.

The RMSC model is based upon distributed and open access, wherein the computing resource architecture is made available based upon a pay-as-you-go model, thereby greatly reduced the capital requirements. Furthermore, by leveraging the on-demand components, the state is not completely burned with a massively depreciating asset. There are various other reasons for the particular nature of the model described in the business plan based upon feasibility assessment.

## ***Objectives and Goals***

In a nutshell, this proposal is a blueprint to help transform the Montana economy through job creation and high technology partnerships involving industry, government, and universities. The explicit goals for this transformation are:

- Drive high-technology job growth;
- Align local businesses with the global economy;
- Promote clean and green energy usage; and
- Renew our communities with restorative developments.

# **The RMSC Blueprint**

## ***Tactical (Intra-State)***

Deploy and operate state-wide centers specializing in supercomputing, data management, networking, visualization, and software engineering capabilities to drive corporate, entrepreneurial, research, and engineering programs State-wide via an integrated, persistent, cyberinfrastructure resources. The tactical deployment of centers will be coordinate with the creation, charter, and certification of Centers of Excellence (COE) aligned with Montana's Certified Regional (Economic) Development Corporations.

## ***Regional (Inter-State and International)***

Create a neighboring state and province cyberinfrastructure grid, connecting both the USA Lambda Rail and Canada's CANAIRE networks, and secure business and research collaborations and projects among participants and the communities.

## ***Strategic***

Use this supercomputing cyberinfrastructure as a framework to help Montana attract factors-of-production to build out a knowledge-based economy for State-wide job growth allowing a community of practice (CoP) to evolve securing new and highly skilled jobs leveraging the investment.

## **Calendar of Events (Timelines)**

Initial State Investment—Phase I: January 2009 (after utilizing initial investment from 2007 Session)

Quick-Start—Phase II: October 2009

State-wide Roll-out—Phase III: June 2010

Regional Roll-out—Phase IV: June 2010

National Roll-out—Phase V: February 2010

International Roll-out—Phase VI: October 2010

## Definitions

**Cyberinfrastructure**—A computing infrastructure based on grids and application-specific software, tools, data repositories, and visualization capabilities that support research, development, and collaborations for a particular discipline. Specifically, a "cyberinfrastructure" is a strategic orientation supported by the US National Science Foundation, calling for large-scale public investment to encourage the evolution of widely distributed computing via the telecommunications network, deploying the combined capacity of multiple sites, to underpin the advance of current research, initially in science and engineering.

**FLOPS**—The speed of a supercomputer is generally measured in "FLOPS" (FLoating Point Operations Per Second), commonly used with an SI prefix such as tera-, combined into the shorthand "TFLOPS" ( $10^{12}$  FLOPS, pronounced teraflops), or peta-, combined into the shorthand "PFLOPS" ( $10^{15}$  FLOPS, pronounced petaflops). This measurement is based on the LINPACK benchmarks.

**HPC**—High Performance Computing (see Supercomputing).

**LINPACK**—A software library for performing numerical linear algebra on digital computers. It was written in Fortran by Jack Dongarra, Jim Bunch, Cleve Moler, and Pete Stewart. The LINPACK benchmarks are a measure of a system's floating point computing power.

**Petascale Computing**—The present state-of-the-art in HPC that leverages the most cutting edge large-scale resources to solve grand challenge problems in science, engineering, government, and business.

**Supercomputing**—A computer that is considered, or was considered at the time of its introduction, to be at the frontline in terms of processing capacity, particularly speed of calculation and storage capacities. The term "Super Computing" was first used by New York World newspaper in 1929 to refer to large custom-built tabulators IBM made for Columbia University.

**Top500 List**— Since 1993, the fastest supercomputers have been ranked on the Top500 List according to their LINPACK benchmark results. The list does not claim to be unbiased or definitive, but it is the best current definition of the "fastest" supercomputer available at any given time.

## Background

### ***Primary Role of Cyberinfrastructure***

Science has withstood centuries of challenges by building upon the community's collective wisdom and knowledge through theory and experiment. However, in the past half-century, the research community has implicitly accepted a fundamental change to the scientific method. In addition to theory and experiment, computation is often cited as the third pillar as a means for scientific discovery. Computational science enables us to investigate phenomena where economics or constraints preclude experimentation, evaluate complex models and manage massive data volumes, model processes across interdisciplinary boundaries, and transform business and engineering practices.

Increasingly, cyberinfrastructure is required to address our national and global priorities, such as sustainability of our natural environment by reducing our carbon footprint and by decreasing our dependencies on fossil fuels, improving human health and living conditions, understanding the mechanisms of life from molecules and systems to organisms and populations, preventing the spread of disease, predicting and tracking severe weather, spread and control of wildfires, recovering from natural and human-caused disasters, maintaining national security, and mastering nanotechnologies.

In production markets, efficiency and productivity matter. Supercomputing continues to grow among both incumbent and new users in classic and non-traditional application areas representing the new face of supercomputing. As supercomputing becomes more commonplace in industry, businesses are finding that they need employees who know how to assemble and maintain these machines. There is an unmet demand.

### ***Supercomputing In Perspective***

In computers, FLOPS are floating-point operations per second. Floating-point is, according to IBM, "a method of encoding real numbers within the limits of finite precision available on computers." Using floating-point encoding, extremely long numbers can be handled relatively easily. The computation of floating-point numbers is often required in scientific or real-time processing applications and FLOPS is a common measure for any computer that runs these applications.

For example, the San Diego Supercomputer Center (SDSC) uses the IBM Blue Gene/L supercomputer with a peak performance of 17.2 TFLOPS (a trillion or million million FLOPS). It would take a person operating a hand-held calculator more than 500,000 years to do the calculations this supercomputer completes every second. It takes 32,000 years for a trillion seconds to tick away.

## Why a Supercomputing Cyberinfrastructure?

Computational needs of technical, scientific, digital media & business applications approach or exceed the petaflop/s range. Figure 1 below outlines some of the supercomputing needs by application or domain.

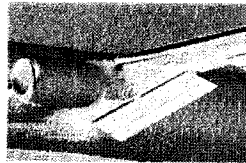


Source: AGM, LGC, M-OSRP

M-OSRP Seismic  
 $45 \times 10^{15}$  FLOPS



Intelligent Oilfield  
 $1.7 \times 10^{21}$  FLOPS



Source: A. Jameson, et al

CFD Wing Simulation  
 $2.1 \times 10^{14}$  FLOPS



CFD Full Plane  
Simulation  
 $8.7 \times 10^{24}$  FLOPS

Digital Movies &  
Special Effects

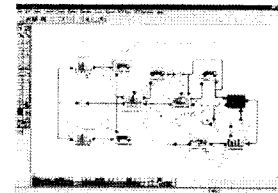
$2.7 \times 10^{19}$  FLOPS



Source: Pixar

Modeling the optimized deployment of  
Spare Parts  
Inventory  
Planning

$2.4 \times 10^{15}$  FLOPS



Source: B. Dietrich, IBM

Figure 1. Why a Supercomputing Cyberinfrastructure.

# Market Analysis

## *Supercomputing Outlook*

### Market Size

The supercomputing market, worldwide, is estimated to reach US\$20 billion for 2008 (IDC, Tabor Research). IDC sees the largest demand for medium to small HPC systems for departments and workgroups, while Tabor Research thinks a new category of HPC "threshold applications" will provide major growth. Factor in other aspects of the HPC market, services and software, it is estimated that the SMB/SME opportunity space is about US\$36 billion (IDC, IBM) and US\$34 billion for the industry systems opportunity space (IDC, IBM).

### Government Involvement

Defense Advanced Research Projects Agency (DARPA) has started the program High Productivity Computing Systems (HPCS) with the declared goal to develop new computer architectures by the end of the decade with high performance and productivity. HPCS has the goal of supporting industry to develop the ability to manufacture and deliver a PetaFLOP-class computer that is substantially easier to program and use than the computers the industry is evolving toward today. The program addresses high-performance computing as an integrated activity involving high-performance computers, programmer and code developers, and production users and seeks improvements in the whole system. A large part of the growth in computer performance is being achieved by increased computer architecture complexity. This makes it very challenging to develop codes to take advantage of the increased computer power.

The HPCS Phase III investment is approximately US\$500M. The DARPA-led program will use money contributed by the NSA and DOE to help fund the effort. Over the next four years, Cray Inc. will receive US\$250 million for their effort, while IBM Corporation will receive US\$244 million. The vendors and their contractors are also expected to make substantial investments in their own systems. According to DARPA, both IBM and Cray are obligated to provide at least 50 percent of the government funding amount in company cost-share.

A goal of HPCS is to reduce the "time to solution" both for production runs and for code development. The HPCS program calls for the development of computer hardware that emphasizes increased computer power for both floating point and integer arithmetic, large memories, and high bandwidth (for low memory latency) and other features that improve the ability of computational scientists and engineers to develop and run codes that can fully exploit the power of supercomputing. The computer vendors (IBM and Cray, Phase III) are looked at what can make a computer that is orders of magnitude more productive than a traditional cluster.

The U.S. government's investment in supercomputing has helped the business sector in several ways. First, programs like HPCS provide critical cost-sharing opportunities to advance supercomputing research and development (R&D). These investments are very important because high-end users have unsolved problems that require us to keep pushing the technology envelope. Petascale problems are not limited to government scientific research. Published cases studies exist confirming the commercial or business industry also has problems needing petascale computing. They exist in the oil & gas and energy industries, the automotive and aerospace industries, and elsewhere.

The U.S. government's investment in purchasing supercomputing systems is also crucial. It not only helps the government meet its mission-critical requirements, it also provides an important revenue stream to the supercomputing vendors so they can invest more in R&D for future-generation HPC systems. Additionally, the government is usually the first to purchase the most advanced systems. As aggressive users with highly complex problems to solve, they push and prove out the technology, providing valuable information back to the hardware and software developers. The developers use this information to make more useable and affordable products, enabling wider adoption of this technology across the private sector. This in turn helps to grow the market and increase our competitiveness. And the healthy cycle continues.

## **Council on Competitiveness**

The Council on Competitiveness has sponsored pioneering studies and conferences on the relationship between HPC and business competitiveness. The Council's HPC Initiative as it works to link together government, academic and business organizations in a "national ecosystem" aimed at advancing innovation and competitiveness through greater use of supercomputing. The Council believes that for the U.S. to remain preeminent in global markets, to increase productivity and raise our standard-of-living, we as a nation must become more innovation-based. The nation as a whole competitive strength is in the ability to be more innovative. Supercomputing and HPC is explicitly linked to innovation and growth. There is a need for pervasive access to and use of supercomputing.

The council's findings are summarized as follows.

- Supercomputing is absolutely essential to business survival.
- Supercomputing must not remain as a computing niche.
- Supercomputing must exploit more fully for greater U.S.A. private sector competitiveness.
- Supercomputing business models exist today that businesses could expand on.
- Supercomputing applications software is extremely important for industry, and a large majority of the ISVs and businesses surveyed are willing to partner with outside organizations to improve the software.

## **Industry Needs**

There are some challenges associated with the widespread adoption of supercomputing by business organizations. Identified by the Council on Competitiveness, these challenges include:

More production-quality application software;  
Better interfaces; and  
More people need to know how to use supercomputing as a production tool.

The people skills and usage gap exists because there is a small group of high-end users and a much larger group of entry-level users, but not many in the middle. The Council on Competitiveness calls this gap in the spectrum the "missing middle." There is another large group of people who are doing technical computing on the desktop, but have not used supercomputing and do not understand its benefits. The Council on Competitiveness calls this group the "never evers."

A major thrust of RMSC and its State acceptance objectives is to address these challenges and industry needs by building a cyberinfrastructure to support and develop the application software and skills base to use supercomputing competitive both in-state and abroad. RMSC will not only address the important needs of high-end supercomputing users, it will also focus on how to fill the "missing middle" and how to encourage the "never evers" to adopt supercomputing for greater competitiveness locally, nationally, and globally.

## **Marketing Plan**

RMSC will develop as its core marketing initiative the Montana Innovation & Technology Ecosystem, or MITE. MITE will link together the key supercomputing constituencies to share expertise and thinking, including organizations from industry, government, academia, vendors, and others. It will also serve as an information exchange or portal to help businesses gain access to the RMSC cyberinfrastructure (hardware, software, networking, and visualization resources housed and supported by ITSD) and expertise.

The aim of MITE is to boost the global competitiveness of Montana businesses by creating a collaborative cyberinfrastructure that will help firms transform ideas into usable products and services. American businesses cannot compete globally based on hourly labor rates—Montana has to compete through ideas and innovation. Leading U.S. corporations in a variety of industries are already doing this by using supercomputing for virtual prototyping, "what-if" analyses and other forms of modeling and simulation. The MITE Initiative needs to make sure all Montana businesses, regardless of size, have the kind of software, expertise and other supercomputing resources they need to remain competitive. Furthermore, the implicit result of the MITE Initiative is to encourage more pervasive use of supercomputing throughout a business' supply chain. As part of MITE, RMSC will also promote supercomputing as an important, exciting career path in our high schools, colleges, and universities—we need to renew our talent stream for the future.

## **Montana Innovation & Technology Ecosystem (MITE)**

RMSC provides a strong starting point to work with government agencies, universities, and private sector industries by serving as a brain trust and provide valuable oversight. The MITE Initiative will support a diverse community in support of its common goal by bringing together many organizations and to have all the major constituencies involved.

There are six key organizing areas with the MITE Initiative.

- Montana needs to understand and incorporate the dynamics of the market and the users for the purposes of this ecosystem. RMSC will build out a roster of corporate, business, and industry partnerships and collaborations along with its activities in the public sector.
- Montana needs to build out the cyberinfrastructure to support supercomputing and do industry pilot studies.
- Montana needs to converge on a backbone infrastructure for high performance computing and communication that's standards-based to the extent possible.
- Montana needs to foster the RMSC Innovation Service Portal where businesses, especially the Council on Competitiveness' "missing middle," "never-overs," and entry-level HPC users, can access supercomputing expertise, cycles, etc. Some of the Montana companies do not need to use supercomputing daily and thus cannot justify creating their own infrastructures.
- Montana needs to create a robust applications software capability that is scalable and ready to use. This will be challenging to accomplish, yet doable by linking to both DARPA's HPCS program and Council on Competitiveness activities.
- Montana needs to focus on training, education, and outreach. RMSC will reach out to universities and high schools, to help create new generations of students who are excited about careers in science and technology, and are prepared to help advance the supercomputing industry and Montana's competitiveness.

All of the organizing areas must work and evolve together. RMSC's "job one" is to get the ball rolling and stay involved; thus, all six of the areas described will move forward in parallel.

## ***Target Market***

### **Market Viability**

The market is untapped in Montana, although latent or what is commonly called non-consumptive. The market opportunity is generally considered to be at least US\$34 billion.

### **Target Audience and Industries**

RMSC will target the following key people to make use of its supercomputing cyberinfrastructure and expertise.

- VPs of Engineering
- VPs of Research & Development
- Line of Business Executives
- Program Executives for the military and government agencies
- Principle Investigators from academia

RMSC will target the following industries (in priority order).

- Oil & Gas, Coal and other clean & renewable energy resources (Upstream, Downstream, and Energy)
- Manufacturing (Concurrent Design and Engineering)
- Life Sciences (Medical Informatics and Scientific)
- Defense and Government
- Academic Research and Development

Industrial and commercial clients, in particular, are looking for ROI in supercomputing and thus will be focus target market for RMSC.

## **Differentiation**

Differentiation formally came almost exclusively from technology inside the “box” and how many boxes where assembled and accessible. Today’s market differentiation is more complex due to the need to incorporate trends in interconnects, file systems, tools, programming models, and people skills—there is so much richness and diversity to the overall supercomputing landscape. Consequently, the industry and marketing intelligence have changed with it. RMSC market differentiation will be based on the execution of its business plan primarily targeting private sector businesses and their needs in Montana and the neighboring region. Differentiation will be characterized as expanding client contexts by making supercomputing more accessible with newly enabled scalable applications (e.g., water management using advanced GIS, consumer manufacturing, online gaming, super-scalable business computing, and much more).

## **Branding**

RMSC, on behalf of Montana, will create a global brand and image around its MITE Initiative and the development and deployment of the cyberinfrastructure support this initiative.

## **Niche**

A niche market is a focused, targetable portion of a market. RMSC will create a niche market in Montana that is by all practical accounts is currently void of supercomputing services and their usages and thus are non-consumptive. The MITE Initiative will create and capitalize on the market niche of Montana clients who can access the RMSC cyberinfrastructure via the Innovation Service Portal.

## **Offerings**

Offerings include the following (and not limited to just these offerings).

- Supercomputing access to RMSC resources (operated and supported by ITSD)
- Supercomputing on demand via IBM’s Capacity on Demand facilities
- Optimization and tuning of applications and systems for supercomputing
- Contracts and grant writing support
- Community outreach, workshops, and training

## ***Supercomputing Workloads, Applications and Domains***

Supercomputing is no longer just for scientists, researchers and academia. Commercial enterprises are also looking for an edge to help solve highly complex problems, perform business-critical analysis or run computationally intensive workloads. These workloads include the following applications or domains.

RMSC and COEs will focus on developing and sustaining State-wide core supercomputing application competencies in:

- Natural Resource Management,
- Aerospace/Aeronautics Research,
- Computational Biosciences Research and
- Complex System Analysis.

Targeted examples are outlined below (but not limited to).

Natural Resource Management activities will focus on the following.

- Application of CFD to reservoir modeling for enhanced fossil fuel recovery, aquifer impact and carbon sequestration potential.
- Climatological modeling for wildfire mitigation, agricultural optimization, remote sensing optimization and other global climate change applications.
- Unexploded ordinance detection/mitigation.

Aerospace/Aeronautics Research activities will focus on the following.

- Application of CFD to next generation flight regimes.
- Multi-scale (time and space) analysis of advanced composite material systems.
- Simulation of material system synthesis and testing.
- Advanced manufacturing process (joining, milling etc.) simulation.

Computational Bioscience Research activities will focus on the following.

- Application of CFD for physiological fluid/structure interaction and material synthesis.
- Multi-scale (time and space) biomolecular structure and dynamics; and
- Simulation of material system synthesis and testing.

Complex System Analysis research activities will focus on the following.

- Sensors/sensor networks for climate, dynamical systems, manufacturing optimization, mechanical system health monitoring, human health monitoring and security applications.
- Data intensive simulations for climate, dynamical systems, manufacturing optimization, mechanical system health monitoring, human health monitoring and security applications.
- Information fusion to extract meaning from complex data for climate, dynamical systems, manufacturing optimization, mechanical system health monitoring, human health monitoring, and security applications.

RMSC will impact virtually every aspect Montana's research enterprises and dramatically impact the State's economic development.

## ***Application and Domain Research Topics***

### **Geologic Carbon Sequestration**

The challenge of multiple scale modeling is to reliably relate the results of physics based analytic tools (such as finite difference approximations of the Navier Stokes equation for porous media flow or of the wave equation for seismic characterization) to field results that likely include the effects of multiple scale heterogeneity not present in the analytic result. The goal is to develop analytic techniques that "fuse" the information from experimental/field results with results obtained from physics based simulations such as CFD simulations of porous media flows, finite difference approaches to wave equation solutions and empirically driven solutions.

### **Wildfire Simulation and Risk Management**

The goal of this program will be develop analytic methods to "fuse" the data generated by physics based computational weather models (such as the Weather Research and Forecasting Model) with experimental/field data, remote sensing data, topographic information and CFD results. The goal is to develop analytic techniques that provide a numerical representation of the relationship between inputs such as biomass energy content, pressure gradients, fluid dynamics and wildfire behavior. These analytic techniques will be capable of real time modeling of the large wildfires (as subsequent release of CO<sub>2</sub>) that we are likely to see in the near future.

### **Unexploded Ordinance Detection/Mitigation**

The Montana Army National Guard is currently engaged in UXO clearance operations in the Limestone Hills and North Helena Valley. It is anticipated that this work will continue at some level for at least the next decade and perhaps longer. In addition to North Helena Valley and Limestone Hills, two other known sites exist near populated areas. At least four other sites are also known to have used live fire training but little is known about their size. Estimated cost for cleanup of all the UXO sites in Montana is in the many hundreds of millions of dollars. Research into improved discrimination methods would center on improvements in forward and inverse modeling of UXO magnetic signatures and applying soft computing techniques (neural networks, fuzzy logic) to integrate validation knowledge into the classification process. The program will also involve developing cost effective sensor and sensor networks systems to accurately track and record current firing range activity in order to reduce future liability.